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FRFP Investigation No. 325. Contract NAS-9-13358

E74-10258) APPLICATION OF EREP IMAGERY
TO FRACTURE-RELATED MINE SAFETY HAZARDS
AND ENVIRONMENTAL PROBLEMS IN MINING

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TITLE: Application of EREP Imagery to Fracture-Related Mine
Safety Hazards and Environmental Problems in Mining

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Original photography may be purchased from
EOS Data Center
10th and Dakota Avenue
Sioux Falls, SD 57198

ABSTRACT

All SKYLAB 2 imagery received to date has been analyzed manually and data related to fracture analysis and mined land inventories has been summarized on map-overlays. A comparison of the relative utility of the SKYLAB image products for fracture detection, soil tone/vegetation contrast mapping, and mined land mapping has been completed.

Numerous fracture traces were detected on both color and black and white transparencies. Unique fracture trace data which will contribute to the investigator's mining hazards analysis were noted on the EREP imagery; these data could not be detected on ERTS imagery or high altitude aircraft color infrared photography. Stream segments controlled by fractures or joint systems could be identified in more detail than with ERTS imagery of comparable scale. ERTS mine hazards products will be modified to demonstrate the value of this additional data.

SKYLAB images were used successfully to update a mined land map of Indiana made in 1972. Changes in mined area as small as two acres can be identified. As the Energy Crisis increases the demand for coal, such demonstrations of the application of SKYLAB data to coal resources will take on new importance.

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OVERALL STATUS

A. Imagery

SKYLAB 2 made a successful, essentially cloud-free pass over the test area on June 10, 1973. A map of the test area and the area covered by the SKYLAB 2 pass (track 33) is shown in Figure 1. SKYLAB 3 made a pass on September 15, 1973 but imagery from that pass has not yet been received. The following image products from the SKYLAB 2 overpass have been received.

- S-192 preliminary multispectral films (bands 2,7,11) which were used for selection of detailed sites for MSS play-outs. The selected area and band requests were forwarded to NASA for processing on September 7, 1973.
- S-190-A multispectral black and white positive film in four bands (500-600nm, 600-700nm, 700-800nm, 800-900nm) in 70 mm format.
- S-190-A multispectral black and white negative and positive films for the same four bands as above in 9 inch format.
- S-190-B natural color (SO-242) film in 5 inch format
- S-190-B natural color (SO-242) film in 9 inch format

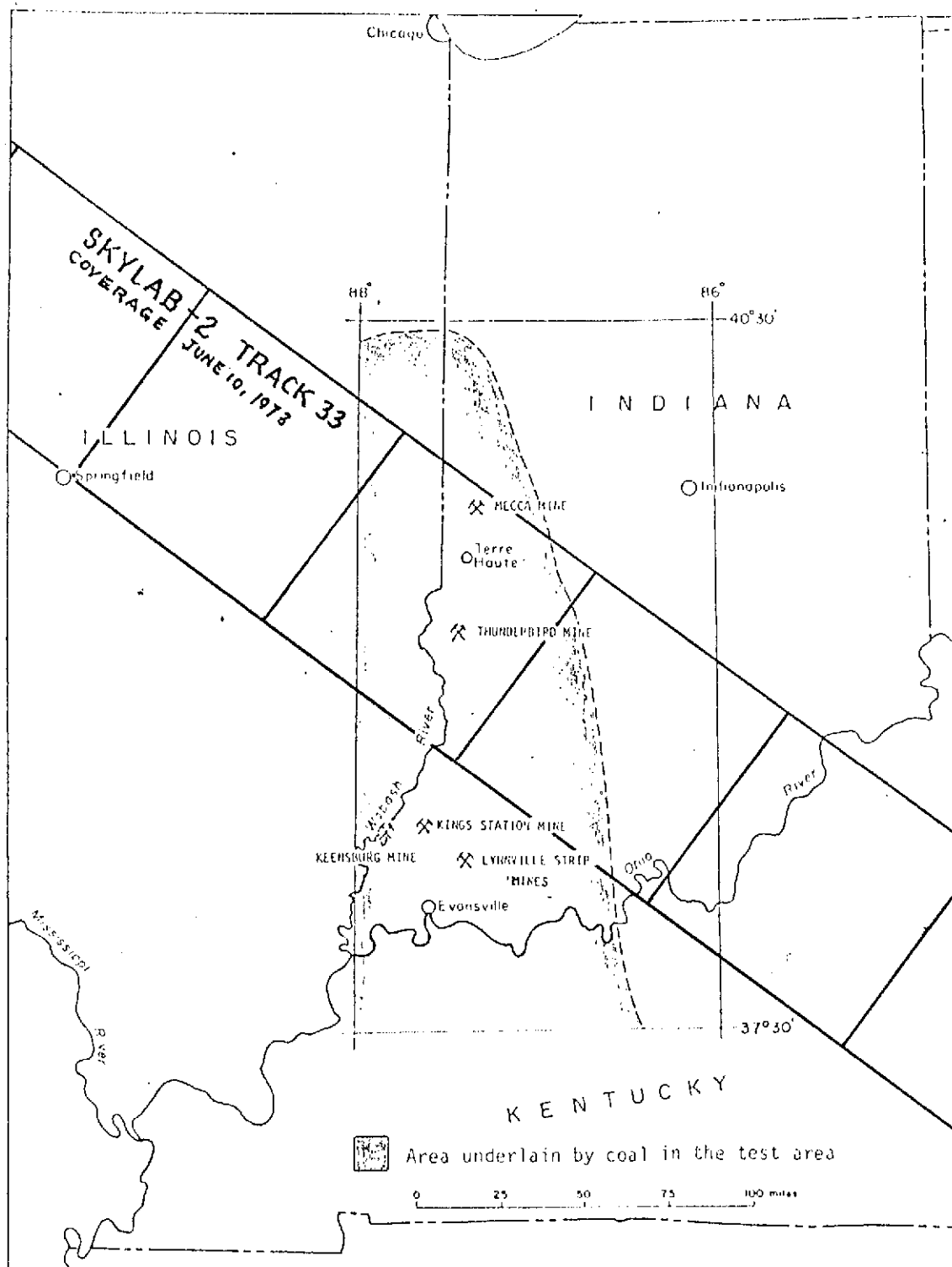


Figure 1. Map of Indiana and parts of Illinois and Kentucky showing the boundaries of the test area and the location of the individual test mine sites.


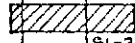
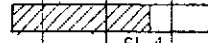











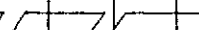



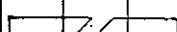





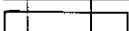
TASK NO.	TASK DESCRIPTION	MONTHS 1973								MONTHS 1974					
		M	J	J	A	S	O	N	D	J	F	M	A	M	J
	SKYLAB MISSIONS														
2.1.1	Prelaunch Preparation														
2.1.2	Milestone Plan														
2.1.3	Ground Truth Support														
	Data Receipt-SKYLAB 2														
2.1.4	Preliminary Analysis of Imagery														
	Data Receipt-SKYLAB 3 Data Receipt-SKYLAB 4														
2.1.5	Analysis of Imagery a. Manual b. Electronic														
2.1.6	Fracture Analysis and Summaries														
2.1.7	Make Environmental Effects of Various Mining Operations a. Coal b. Limestone c. Sand and Gravel														
2.1.8	Comparison of Data with ERTS-1														
2.1.9	Make Data/Products Available to State														
3.0	Reporting														

Table 1. Task Progress Summary for EREP Investigation No. 325

B. Project Management

All prelaunch preparations have been completed and a Milestone Plan has been submitted. All SKYLAB 2 imagery received to date has been analyzed manually and data related to fracture analysis and mined land inventories has been summarized on map-overlays. Enlargements of SKYLAB images have been made to determine the utility of the imagery at various scales. Scales tested were 1:500,000, 1:250,000, 1:100,000, and 1:24,000. SKYLAB 2 data which has not been received includes the S-192 multispectral playout in 24 channels and the S-190-A color and color infrared (cameras 3 and 4) in 9 inch format.

Ground truth data were collected during the SKYLAB 2 pass. SKYLAB 3 pass data was not acquired because the pass did not cover the test mine sites. It is anticipated that ground truth will be obtained if a cloud-free SKYLAB 4 pass can be made.

A task progress summary for this investigation is shown in Table 1.

RECOMMENDATIONS:

Because of the delays involved in receiving SKYLAB imagery, it is unlikely that the project can be completed by June 30, 1974.

If SKYLAB 4 images are obtained and used in the analysis, assuming a four months delay in receipt of imagery, this data could not be utilized to meet the contract deadline June 30, 1974. It is therefore recommended that the project be extended two (2) months to August 30, 1974 to enable the investigators to utilize all SKYLAB image products and incorporate all findings in the final report.

Additional funding for product development could result in major benefits to the SKYLAB Program. In particular, funds are needed to prepare practical mine safety, mine subsidence and mining-environmental (reclamation) products as tangible illustrations of unique SKYLAB data applications and in sufficient numbers for use by Indiana, reference by other coal producing states, and for NASA distribution. An important opportunity to utilize SKYLAB data for critical Indiana State Legislative decisions related to energy has developed. During the Energy Crisis, such demonstrations of the applications of SKYLAB data to coal resources will take on new importance.

EXPECTED ACCOMPLISHMENTS:

- Additional geological fracture data to supplement ERTS-1 Mine Safety (roof fall and subsidence) Investigation will be gained.
- Additional environmental data on mined lands will be generated. EarthSat's prototype National Mined Lands Inventory Map at 1:250,000 scale and other mined land inventory products can be updated effectively.
- Emphasis will be placed on the early reporting of significant results and uses of SKYLAB data.
- Areas mined for non-fuel mineral resources including sand and gravel, limestone, and clay, will be studied.

- Areas of environmentally degrading features which result from mining activities (such as mine refuse dumps, slurry ponds, acid mine drainage, and mine subsidence) will be identified.
- Products derived from the data provided by all successive SKYLAB overpasses will be comparatively analyzed to determine the amount of new mining and reclamation progress between each overpass.
- Products will be made available as possible 1/ to operating state/county agencies so that the utility and benefits of SKYLAB data can be evaluated.
- Efforts will be made to broadly identify the Energy-related contributions of SKYLAB data.

SIGNIFICANT RESULTS:

A. Energy Crisis

Several groups have suggested that the integrated application of ERTS and SKYLAB data in Indiana is having definable peripheral solutions to mining issues related to the national Energy Crisis.

B. Mine Safety/Hazards Analysis

Numerous fracture traces were detected on both the color and black and white transparencies. A large percentage of fields were in a fallow state at the time of SKYLAB overpass; this permitted the detection of fractures (expressed tonally) extending across field boundaries. Unique fracture trace data which will contribute to the investigator's mining hazards analysis were noted on the EREP imagery

1/ Within funding limits (see recommendations)

these data could not be detected on ERTS imagery or high altitude aircraft color infrared photography. Stream segments controlled by fractures or joint systems could be identified in more detail than with ERTS imagery of comparable scale. ERTS mine hazards products will be modified to demonstrate the value of these additional data within Indiana.

A comparison of the utility of SKYLAB 2 image products for fracture analysis, soil and vegetation tone mapping, and mined land mapping is shown in Table 2. The S-190B color and S-190A mag. 11 (600-700nm) films provided the most data.

Tone changes indicative of soil changes and vegetational types were noted in all SKYLAB 2 imagery. Table 2 compares the image products for their relative utility in mapping these tonal changes. Many tonal variations in the Illinois and Indiana portions of the imagery proved indicative of the different types of glacial materials which cover the test site. On the basis of these tonal changes, Wisconsin- and Illinoian-age drift including ground and end moraines can be differentiated. Glacial lake deposits, outwash deposits, and alluvial valleys can also be mapped.

Film Type	Fracture Detection Capability	Soil Tone/Vegetation Contrast Mapping Capability	Mined Land Mapping Capability
S-190A-07 Pos. Transp.	X	XX	X
S-190A-08	XX	XX	X
S-190A 11	XXX	XXX	XXX
S-190A 12	XX	X	X
S-190A-07 Neg. Transp.	XX	XXX	X
S-190A 08	XX	XX	X
S-190A 11	XXX	XX	XX
S-190A 12	XX	X	X
S-190B Color	XXX	XX	XXX

EXPLANATION

Spectral bands

S-190A-07 700-800 nm
 S-190A-08 800-900 nm
 S-190A-11 600-700 nm
 S-190A-12 500-600 nm
 S-190B Color 400-700 nm

Film Utility Rating

X = poor detectability
 XX = good detectability
 XXX = excellent detectability

TABLE 2. Comparison of the utility of SKYLAB 2 image products for fracture detection, soil tone and vegetation contrast mapping, and mined land mapping capabilities.

C. Mined Land Inventory and Reclamation

1. Surface Mining for Coal

EREP photography provides additional data over comparable scale ERTS imagery. Variations in the percentages of mined lands vegetative cover can be defined. SKYLAB provides an accurate data base from which changes in (for example) percentage of vegetative cover in mined areas or changes in mined areas could be updated by the use of successive ERTS overflights.

A 1:250,000 scale black and white enlargement of SKYLAB 2 imagery (S-190-B color) was prepared to compare strip mining progress (Figure 2) with a recently published (June, 1972) strip mined area map of Indiana ^{1/}. This analysis revealed significant advances of strip mines in the Dugger, Jasonville, and Sullivan areas and the opening of a new mine near Hymera. Land which has been strip mined and reclaimed recently (within the past 5 years) is evident; however, older mined lands overgrown with trees are usually difficult to differentiate from the nearby unmined farm and forest lands. Changes in mined area as small as two acres can be identified on the imagery.

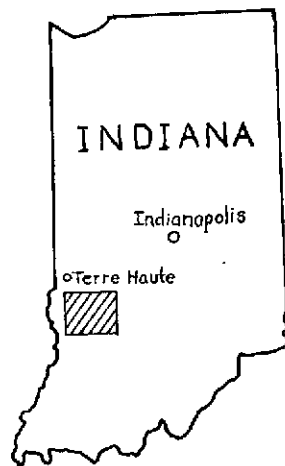
2. Non-Fuel Mining

A review of EREP color photography (1:1,000,000 and 1:500,000 scales) permitted the identification of a substantial number of

^{1/} Powell, R.L., 1972, Map of Southwestern Indiana Showing Areas Strip Mined for Coal. Indiana Geological Survey, Miscellaneous Map No. 15.

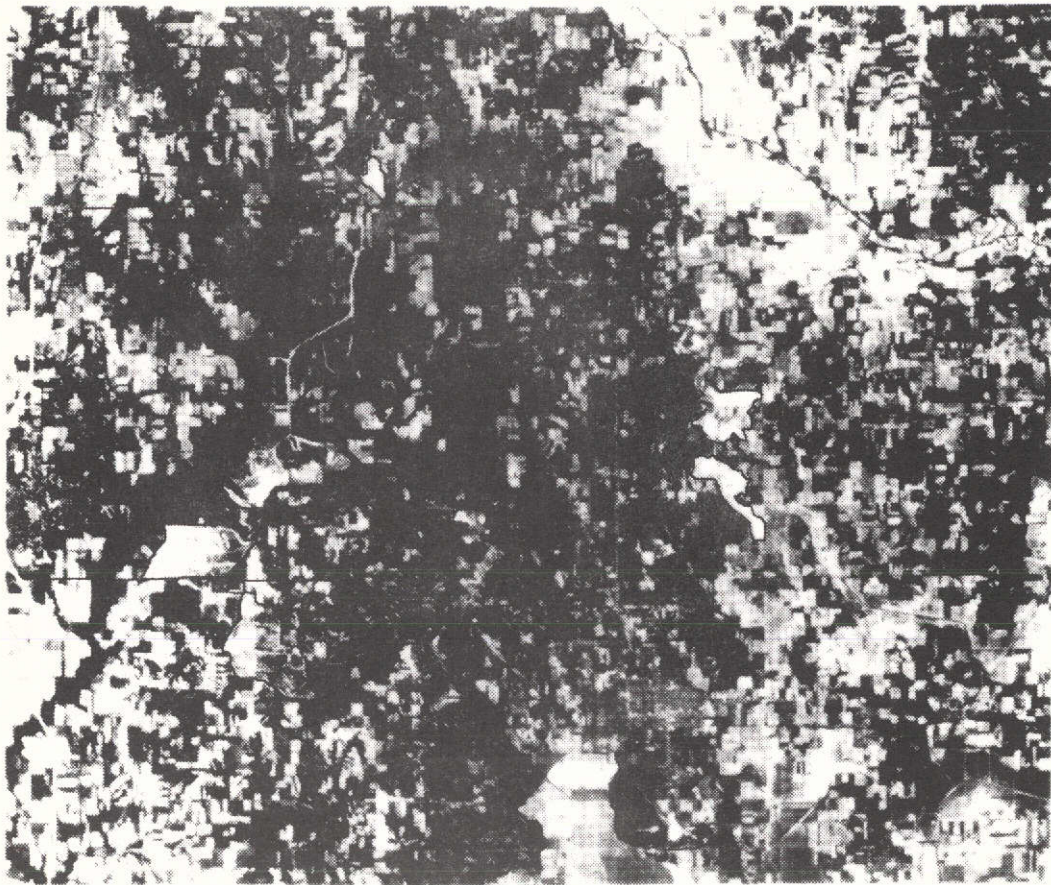
FIGURE 2.

- A. Black and white reproduction of SKYLAB S-190B imagery acquired on June 10, 1973, enlarged to a scale of 1:250,000 showing recent strip mining for coal in the area east of Sullivan, Indiana. The location of this area is shown in the diagram below. Older strip mines in the center of the image are not evident as they have become overgrown by trees and blend with the surrounding forested lands.

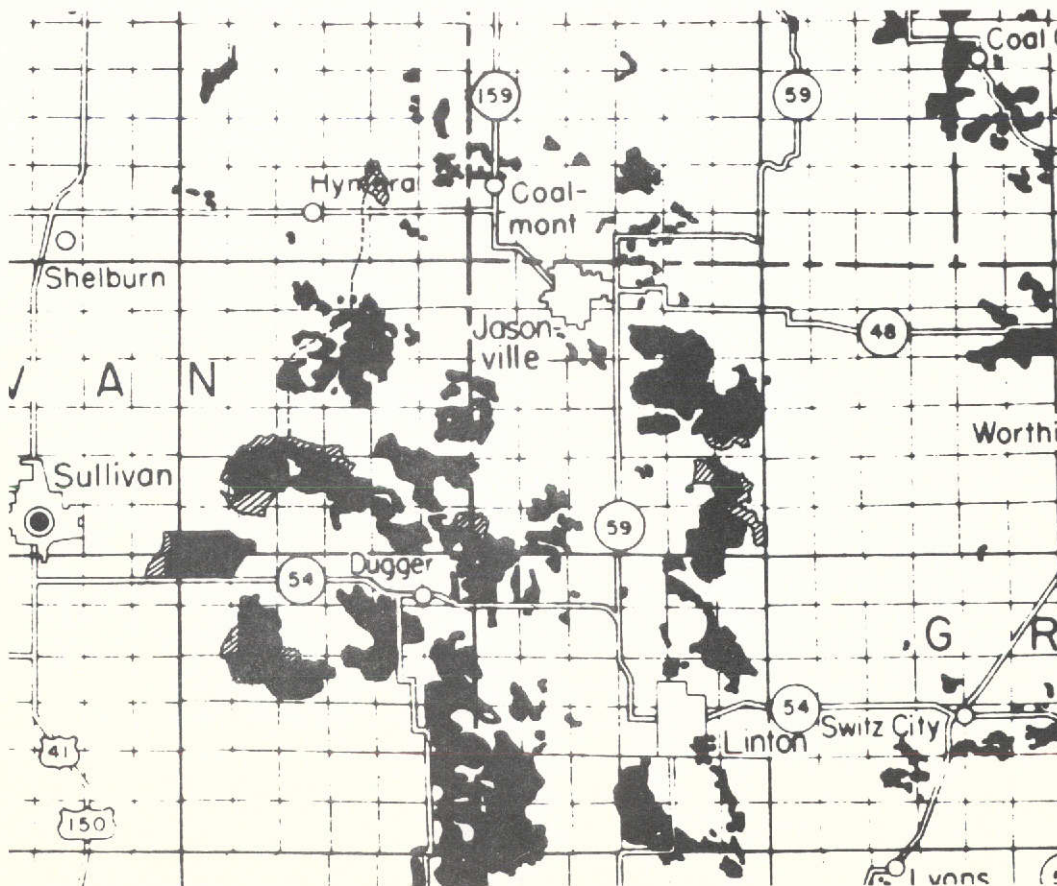


- B. Map 1/ of the same area and at the same scale as the image shown above delineating areas strip mined for coal up to June 1972. The areas shaded by diagonal lines indicate areas which have been strip mined during the year between the map compilation and the SKYLAB 2 overpass.

1/ Powell, R.L., 1972. Map of Southwestern Indiana Showing Areas Strip Mined for Coal. Indiana Geological Survey, Miscellaneous Map No. 15.



A.



B.

non-fuel (limestone, sand and gravel, clay, etc.) mines within the Southern Indiana Test Area. Comparison with historical (1970 and 1971) small scale aerial photography revealed changes in mined area and other evidence of active (or recently active) mining sites.

SUMMARY OUTLOOK:

Based on a comparison of EREP with ERTS-1 and high altitude aircraft imagery of Indiana, SKYLAB imagery complements ERTS-1 and high-altitude aircraft imagery as an intermediate resolution product. Funding constraints are proving the only reason why a comprehensive series of user-oriented operational SKYLAB products will be unavailable to coal producing states and for NASA use.

TRAVEL SUMMARY AND PLANS:

No trips were made during the third quarterly reporting period. Travel plans have not been made for the next reporting period to conserve funds for products where possible.